

*As part of a longitudinal study of child health and development, the authors of this paper report on respiratory infections among a group of children followed periodically from birth to age 18. The variations experienced by the members of the group are analyzed and discussed. Implications for further research are indicated.*

## **CONTRIBUTION OF RESPIRATORY INFECTIONS TO THE TOTAL ILLNESS EXPERIENCES OF HEALTHY CHILDREN FROM BIRTH TO 18 YEARS**

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**T**HIS paper reports on the respiratory infections experienced by 134 children, 67 boys and 67 girls, who constitute the Maturity Series of the Longitudinal Studies of Child Health and Development, conducted since 1930 by Dr. Harold C. Stuart at the Harvard School of Public Health. These children were followed periodically from birth to their 18th year by a staff representing several disciplines. The research program has been described by Dr. Stuart in a Supplement to the November, 1959, issue of Pediatrics.<sup>1</sup>

The basic data on illness were collected through health histories and pediatric physical examinations at three-month intervals during the first two years, six-month intervals from two to ten years, and annually thereafter.

This report deals separately with the several types of common respiratory illnesses as well as the less common specific respiratory complications. Its goals are to provide cross-sectional information which gives the range of individual variations quantitatively and qualitatively at successive age periods, and longitudinal information on individual patterns.

### **Methodology**

#### **Definition of Respiratory Illness**

Included in respiratory illnesses are those which manifest any of the wide range of symptoms or signs of involvement of the respiratory passages. However, these were included only when they appear as the primary manifestations of the diseases and not merely accompaniments of more general illnesses or prodromal signs of a communicable disease. In counting the number of illnesses it was sometimes difficult to distinguish between exacerbation with remissions and recurrences after recovery. This applies particularly to minor illnesses which were usually not seen by a physician. Unless separated by a complete symptom-free period, successive recurrences were counted as one illness.

#### **Scoring System**

In order to assess the impact of illness on the child's health, a numerical score was assigned to each illness on a predetermined scale, which has been more fully described elsewhere.<sup>2</sup> The basic unit of "1" was assigned to a respiratory illness with evidence of in-

involvement of both upper and lower respiratory areas, of moderate severity, lasting a week. Adjustment of the score for other respiratory illnesses took into account symptomatology, extent of involvement, complications, and duration. Although it is not always possible to assign a precisely accurate score to a particular illness, especially one of long duration and changing severities and involvements, two of the authors have found it possible to check with satisfaction ratings of cases chosen at random, except in occasional long and complicated cases which required joint review and discussion. Any illness of considerable duration is likely to have changing severity ratings with time. For example, a long illness might be assigned a rating of "severe" for one week, of "mild" for a second, a recurrence of "severe" for a third, of "moderate" for the fourth, and again "mild" for a fifth and last. It might well be that the mildness of the reported symptoms during the second week would lead investigators to report this whole episode as two illnesses separated by recovery during the second week. In our scoring system, dropping out the "mild" rating for the second week would have changed the number of illnesses from one to two but would only have reduced the total score by  $\frac{1}{4}$  point.

#### Classification

Bacteriological studies were not made for identification and isolation of etiologic agents, except when children were hospitalized, so no attempt has been made to classify respiratory infections (RIs) according to their etiology; neither have anatomic distinctions provided the primary basis for classification of respiratory illnesses. The basis for classification was the extent of involvement, the severity, and the specific complications noted, as for example, otitis media or pneumonia. Recognition of these has seemed more important in this study than assigning exact diagnosis.

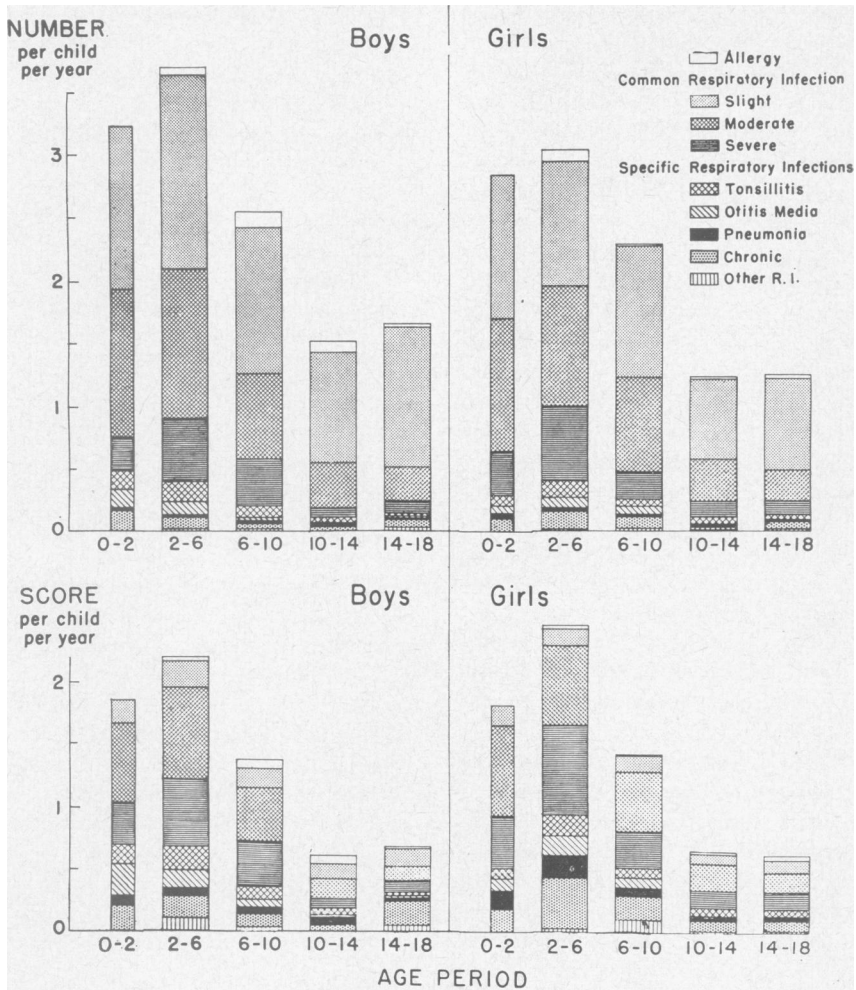
The classification adopted is the following:

- I. Common Acute Respiratory Infection—Slight, moderate, severe.
- II. Specific Respiratory Infections—Tonsillitis, otitis media and pneumonia which were included only when there was specific proof such as physician's diagnosis or evidence of recent infection at physical examination. They were fewer in number than the common respiratory infection and were not subdivided according to severity; however, severity is demonstrated in their respective scores.
- III. Chronic or Prolonged Respiratory Infections.
- IV. Other Respiratory Infections—Include miscellaneous diagnoses such as mastoiditis, sinusitis, and so forth, which were too few in number to constitute each a separate category.

The respiratory infections might include many undiagnosed allergic reactions in the respiratory tract. Only known allergies, such as hay fever, asthma, or repeated "cold," which after skin tests proved to be allergic, are listed under the subgroup "allergy."

Respiratory illnesses constitute 83 per cent of the number of total illnesses experienced by boys and girls from birth to 18 years.<sup>3</sup> At all age periods the percentages of total illnesses which are respiratory are high. This is strikingly apparent from the following figures given in round numbers: 85, 82, 81, 79, and 91 per cent for boys at the successive age periods of infancy, preschool, school, early and late adolescence were respiratory. For girls the comparable percentages are 81, 82, 80, 83, and 91 per cent. The lowest percentage of respiratory illnesses was 79 for boys during early adolescence, whereas the highest was 91 for both boys and girls during late adolescence.

Figure 1 presents the respective values of number and score for respiratory allergies and infections of the types defined in this classification. These are given by age periods, for boys and girls separately. The chart is composed of



**Figure 1—Respiratory Illnesses by Number and Score for Boys and Girls by Age Periods**

four parts: The upper two give the number for boys on the left and girls on the right; the lower two give their scores. Each vertical column represents one age period as indicated. Within each column values of number and score for each type of respiratory illness are superimposed in the order which is shown in the key. This chart summarizes graphically the data presented in actual values in Tables 1 and 2. The discussion here relates to the graphic presentation.

Known allergies form a small part of

respiratory illnesses. No case was recognized in this group in infancy. Pre-school boys had 18 and girls had 23 allergic illnesses accounting only for 1.80 per cent and 2.82 per cent, respectively, of the total respiratory illnesses at this age. In succeeding age periods the number of allergies increased for boys; the peak at the school-age period was 29 or 4.26 per cent. During the entire period of study the boys had about twice as many allergies as the girls. Almost all of the differences between the sexes occurred during the school and early

adolescent years when the boys had their maximum occurrences of allergies and the girls had very few. The corresponding scores present a similar trend, the score values being less than the number except in late adolescence for girls; here, girls' score exceeds boys' and, in addition, their score is greater than their number which was due to more long-duration allergies.

The total numbers of respiratory infections (shown in the columns by all the shaded areas) were at all age periods greater for boys than girls. The total scores for both sexes were less than the

corresponding number at all age periods, which means illnesses were on the average mild to moderate; scores were more alike for both sexes except in the preschool period when the girls' score was higher. For both sexes the preschool-age period represented the greatest number and score. The next highest rates of illness were found in infancy.

"Slight" and "moderate" respiratory infections constitute the majority of the number of respiratory infections at all ages, in both sexes. The smallest contribution of these two categories was 66 per cent of the illnesses among girls from

**Table 1—Proportion of Infections and Known Allergies Among Total Number and Score of Respiratory Illnesses by Sex and Age Period**

Sex and Age	Total Respiratory Illnesses	Infections		Known Allergies	
	Number	N	%	N	%
Boys					
0- 2	431	431	100.00	—	—
2- 6	997	979	98.20	18	1.80
6-10	681	652	95.74	29	4.26
10-14	409	384	93.89	25	6.11
14-18	445	439	98.65	6	1.35
Girls					
0- 2	379	379	100.00	—	—
2- 6	815	792	97.18	23	2.82
6-10	613	612	99.84	1	0.16
10-14	331	326	98.48	5	1.52
14-18	335	327	97.61	8	2.39
	Score	S	%	S	%
Boys					
0- 2	248	248	100.00	—	—
2- 6	589	581	98.56	8	1.44
6-10	371	353	95.18	18	4.82
10-14	165	146	88.42	19	11.58
14-18	182	180	98.70	2	1.30
Girls					
0- 2	241	241	100.00	—	—
2- 6	659	652	98.96	7	1.04
6-10	380	380	99.90	—	0.10
10-14	174	169	97.12	5	2.88
14-18	167	156	93.70	10	6.30

Fractions under  $\frac{1}{2}$  have been dropped; those over  $\frac{1}{2}$  have been raised to the next unit.

Table 2—Distribution of Total Number and Score of Respiratory Infections by Type of Infection by Sex and Age Period

Sex and Age	Total Respiratory Infections	Common						Specific									
		Slight		Moderate		Severe		Tonsillitis		Otitis Media		Pneumonia		Chronic		Other	
		Number	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Boys																	
0-2	431	173	40.13	157	36.43	36	8.35	20	4.64	20	4.64	3	0.70	22	5.10	—	—
2-6	979	418	42.70	320	32.69	134	13.69	45	5.01	25	2.55	4	0.41	31	3.17	2	0.20
6-10	652	313	48.00	183	28.07	101	15.49	24	3.68	10	1.53	5	0.77	12	1.84	4	0.61
10-14	384	238	61.98	96	25.00	20	5.21	12	3.12	1	0.26	6	1.56	11	2.86	—	—
14-18	439	310	70.62	64	14.58	26	5.92	8	1.82	4	0.91	2	0.46	19	4.33	6	1.37
Girls																	
0-2	379	152	40.11	142	37.47	47	12.40	11	2.90	8	2.11	6	1.58	13	3.43	—	—
2-6	792	266	33.59	257	32.45	161	20.33	35	4.42	23	2.90	9	1.14	39	4.92	2	0.25
6-10	612	280	45.75	205	33.50	58	9.48	16	2.61	16	2.61	6	0.98	27	4.41	4	0.65
10-14	326	170	52.15	93	28.53	33	10.12	17	5.21	1	0.31	2	0.61	9	2.76	1	0.31
14-18	327	195	59.63	69	21.10	28	8.56	12	3.67	—	—	3	0.92	18	5.50	2	0.61
Score		S	%	S	%	S	%	S	%	S	%	S	%	S	%	S	%
Boys																	
0-2	248	24	9.77	86	34.74	44	17.52	21	6.95	34	14.25	10	4.08	27	11.08	—	—
2-6	581	57	9.81	184	31.77	159	27.42	48	8.31	41	7.10	14	2.41	50	8.57	27	4.61
6-10	353	42	11.93	98	27.68	115	32.71	31	8.92	14	3.89	14	3.96	30	8.37	8	2.34
10-14	146	30	20.63	47	31.93	20	14.04	14	9.59	2	1.71	21	14.21	11	7.88	—	—
14-18	180	40	22.14	28	15.68	29	15.96	7	3.75	4	2.50	6	3.33	52	29.01	14	7.63
Girls																	
0-2	241	21	8.76	97	40.12	56	23.17	11	4.77	13	5.29	19	7.88	24	10.01	—	—
2-6	652	35	5.41	174	26.72	195	29.90	41	6.25	43	6.67	48	7.36	110	16.93	5	0.77
6-10	380	39	10.64	123	32.40	81	21.47	20	5.27	23	6.06	17	4.48	51	13.16	25	6.59
10-14	169	23	13.77	56	33.31	36	21.10	19	11.25	1	0.88	6	3.55	25	14.95	2	1.18
14-18	156	28	17.76	41	26.08	38	24.48	13	8.16	—	—	9	5.76	24	15.52	3	2.24

Fractions under 1/2 have been dropped; those over 1/2 have been raised to the next unit.

ages 2 to 6 and the largest contribution was 97 per cent of the illnesses among boys from ages 10 to 14.

The score values by definition place less importance upon the "slight" respiratory infections and increase the relative contribution of such categories as chronic infections, otitis media, tonsillitis, and pneumonia. The largest contributions to the total scores are generally made by "moderate" and "severe" respiratory infections.

Figure 2 presents the distribution of children by number of illnesses for each age period and each type of respiratory infection. The chart is divided into five vertical columns for the five age periods adopted. Each column is divided horizontally into eight. Within each of these, boys and girls separately are distributed by the number of illnesses each individual experienced. The vertical scale of each type of RI represents number of illnesses and each dot of the chart represents one child.

This chart shows that:

1. For all types of respiratory infections, for boys and girls, the preschool-age period is not only the period of maximum number of illnesses as shown previously, but the period in which the maximum number of children experienced each type of RI.

2. At all age periods, "slight" and "moderate" respiratory infections were experienced by the greatest number of children, the number falling sharply, almost by one-half, for "severe" RI and more sharply for the rest of RI types.

3. In addition, the greatest range of variation in the number of respiratory infections per child was found in the slight and moderate categories (i.e., from 1 to 20); the greatest number of children had more than 5 or 10 illnesses each.

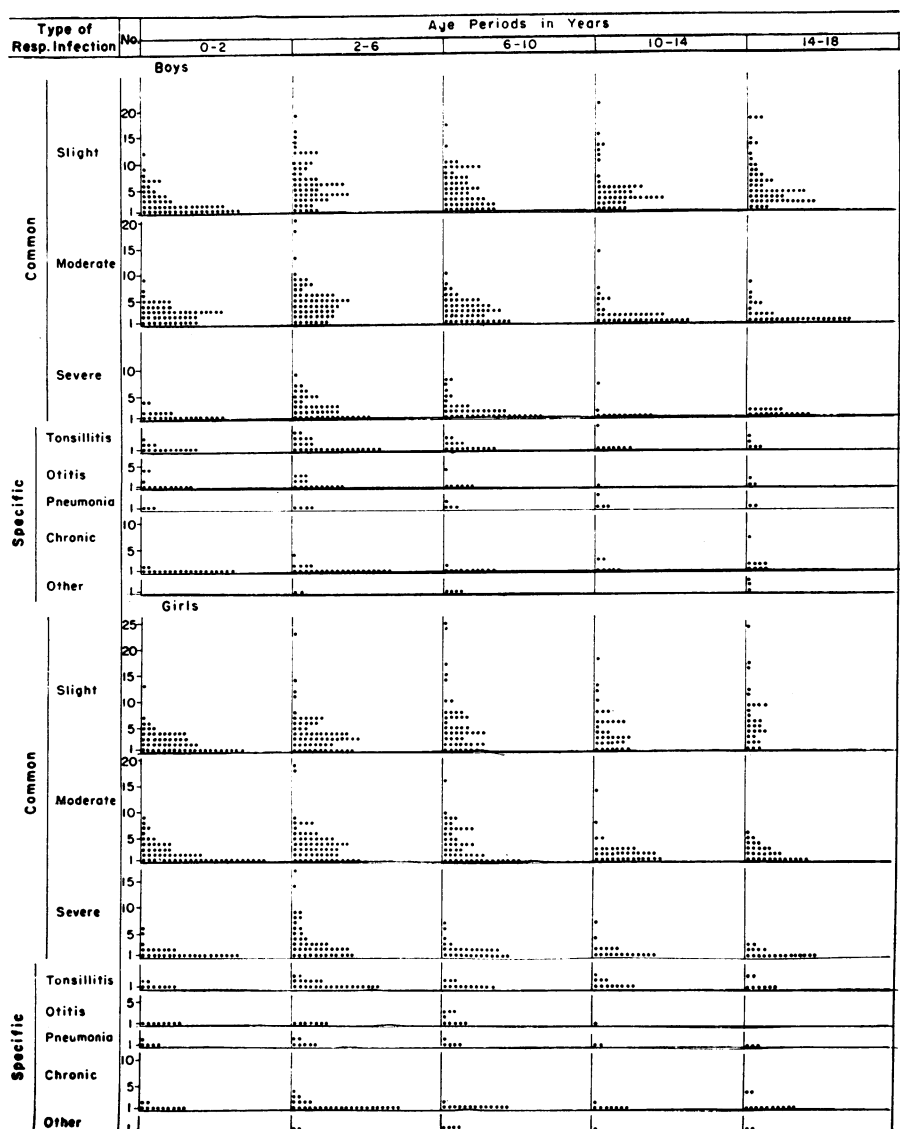
The distribution of the children according to the number of illnesses experienced by each individual makes it possible to determine whether the episodes of illness were distributed at random over the children, that is, whether the risk of illness was the same for all children. For each of the commonly

occurring categories, i.e., slight, moderate, and severe respiratory infections in all five age periods and among children of both sexes, there was evidence of variation in the risk of illness from child to child. Some children completely escaped a given type of illness during an age period when others were suffering repeated attacks, and these differences were consistently greater than chance expectation. This was most strikingly the case during the early and late adolescent periods for boys and during the school and adolescent periods for girls. Thus, for example, during early adolescence 50 boys had an average of 4.8 per cent slight respiratory infections each, while 17 boys reported no such illnesses. During the same age period 37 girls reported 4.6 per cent slight respiratory infections per child, while 30 girls had no slight respiratory infections recorded.

To investigate further the differences in the amount of respiratory infections experienced by individual children, we studied the changes each child presents throughout childhood, taking score as the only criterion.

For each age group, boys and girls are ranked separately in order of increasing values for scores for respiratory illnesses, and divided into the low 25 per cent, the middle 50 per cent, and the high 25 per cent. These groups were identified by letters L, M, and H, the letter O indicating that the child had no respiratory illness at all.

For each child the ratings were put into sequence in age-period order of infancy, preschool, school, early and late adolescence. These age-period sequences showed trends which are presented in Table 3. It is found that 54 vary between L and M, 34 between M and H, making 88 children who retain relatively constant rank position throughout childhood, while 46 children, or one-third of the children, vary in their positions between O, L, M, and H.



**Figure 2—Distribution of Children by Number of Illnesses for Each Age Period and Each Type of Respiratory Infection**

In order to get more insight into the factors which contribute to these differences in trends, we studied the incidence of "high" position of any type of respiratory infection at any age period. Table 4 shows that among children who varied between L and M, 43 per cent had "high" position in scores for "slight"

respiratory infection, 30 per cent had "high" position in "moderate" ones, and much lesser proportion in the rest of the categories. By contrast, among children who remained constantly between M and H, not only is there greater proportion of children who had "high" positions in the "slight" and "moderate"

**Table 3—Changes in Score Ranking for Respiratory Illnesses Throughout Age Periods**

	Total	Score Position Varying Between:		
		O,L&M	M&H	O,L, M&H
Constant				
Low	4	4		
Medium	9	9		
High	4		4	
Ascending	15	7	6	2
Descending	18	9	6	3
Ascending- descending	29	4	8	17
Descending- ascending	23	8	3	12
Ascending- descending- ascending	11	3	1	7
Descending- ascending- descending	18	8	6	4
Other	3	2	0	1
Total	134	54	34	46

types, but there is a tremendous difference in the "severe" types (64 per cent of children against 12 per cent in the first group); in tonsillitis (21 per cent against 14 per cent); in otitis media (18 per cent against 3 per cent); pneumonia (9 per cent against 0); and chronic infections (33 per cent against 12 per cent).

Children in the third group, with

marked changes in position, present values in-between the two other groups for the common respiratory infections. They are more similar to those who remained between M and H for tonsillitis, pneumonia, and chronic infection; but definitely more (11 per cent) children had "high" position in "other" respiratory infections, the type which includes a miscellaneous diagnosis of infections which were each too few to constitute a specific type.

We can then say that in a general way children tend to remain rather constant in rank position for respiratory illnesses throughout the various age periods of childhood. To what extent can predictions be made from one period to the next is an important question, the answer to which will help us in planning ahead for the health supervision of individual children.

Among the 34 children with "high" ratings in infancy, only 4 remained very consistently "high" throughout childhood, but 16 remained relatively constant, varying between M and H; of these 7 presented a descending trend, 3 descending-ascending, and 6 descending-ascending-descending. This means that 20 children or more than half (59 per cent) of those who started "high" remained relatively high throughout childhood. Fourteen children presented marked changes in their positions, that is, varied between O, L, M and H; among these, 10 followed a descending-

**Table 4—Percentages of Children with "High" Score During at Least One Age Period for Types of Respiratory Illness**

	Common RI			Specific RI				
	Slight	Moderate	Severe	Tons.	O.M.	Pneu.	Chro.	Other
Score positions between L&M	43	30	12	14	3	0	12	1
Score positions between M&H	76	76	64	21	18	9	33	3
Score positions between L&H	73	53	51	22	7	8	27	11



ascending trend (3 had L in preschool-, 5 in school-, and 2 in early-adolescence-age periods); 3 followed a descending trend; and 1 descending-ascending-descending. In other words, 41 per cent of the children who started "high" changed markedly in their position; of these, 71 per cent had a descending-ascending trend.

By contrast, among the 34 children who rated "low" in infancy, 4 continued "low" and 14 varied between L and M. Thus, 18 children or 53 per cent of those who started "low" remained relatively constant. Sixteen children or 47 per cent changed markedly; of these 12 followed an ascending-descending trend (7 had a peak in school, 3 in early adolescence, and 2 in preschool).

In other words, more than half of the children remained relatively constant (either L to M or M to H) in their ratings. That does not mean they will continue to have the same score, since the general trend of changes of score by age periods for the 134 children was a decreasing one from preschool to adolescence. A boy who is consistently "high" will have scores in the successive age periods from infancy to late adolescence which are more than 5, 10,  $7\frac{1}{4}$ , 3, and 3, respectively. For a girl, high scores would fall above 5, 12,  $8\frac{1}{2}$ ,  $2\frac{1}{2}$ , and 4. By the same token, a boy will be consistently "low" if he had under  $1\frac{1}{2}$  units in infancy, under  $4\frac{1}{2}$  in preschool, under  $2\frac{1}{2}$  in school, under  $\frac{5}{8}$  in early adolescence, and under  $\frac{3}{4}$  in late adoles-

cence. A girl will be "low" if she had under  $1\frac{3}{8}$ , 4, 2,  $1\frac{1}{8}$ , and  $1\frac{1}{8}$ , in the same sequence of age periods.

Because of the limitation of the size of the group, we can only draw tentative conclusions. These are, nevertheless, of potential use in our planning ahead for health supervision. We definitely have to be alert in following children who have "high" amount of respiratory illnesses in infancy. On the basis of this study, 59 per cent of them may continue with "high" or "moderate" illness throughout childhood, and it is among them that higher proportions of severe respiratory infections of the common types as well as otitis media, pneumonia, chronic infections are to be found. This hypothesis needs to be explored more on larger numbers of children of different racial and socioeconomic groups, living in different environments, to gain insight of the risks at different ages. The great contribution of longitudinal studies is to bring not only hypotheses to light, but to bring out methods of study which can be applied more easily in studies of non-longitudinal character.

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